AL/HR-TP-1995-0006

ARMSTRONG LABORATORY

DIFFERENTIAL ASSIGNMENT POTENTIAL IN THE ASVAB: A SIMULATION OF JOB PERFORMANCE GAINS

William E. Alley

HUMAN RESOURCES DIRECTORATE
MANPOWER AND PERSONNEL RESEARCH DIVISION
7909 Lindbergh Dr.
Brooks Air Force Base, Texas 78235-5352

Mark S. Teachout

HUMAN RESOURCES DIRECTORATE
TECHNICAL TRAINING RESEARCH DIVISION
7909 Lindbergh Dr.
Brooks Air Force Base, Texas 78235-5352

June 1995

Interim Technical Paper for Period January 1992 - December 1994

AIR FORCE MATERIEL COMMAND
BROOKS AIR FORCE BASE, TEXAS

NOTICES

Publication of this paper does not constitute approval or disapproval of the ideas or findings. It is published in the interest of scientific and technical information (STINFO) exchange.

When Government drawings, specifications, or the data are used for any purpose other than in connection with a definitely Government-related procurement, the United States Government incurs no responsibility or any obligation whatsoever. The fact that the Government may have formulated or in anyway supplied the said drawings, specifications, or other data, is not to be regarded by implication, or otherwise in any manner construed, as licensing the holder, or any other person or corporation; or as conveying any rights or permission to manufacture, use, or sell any patented invention that may in any way be related thereto.

The Office of Public Affairs has reviewed this paper, and it is releasable to the National Technical Information Service, where it will be available to the general public, including foreign nationals.

This paper has been reviewed and is approved for publication.

Mark S. Teachout
MARK S. TEACHOUT
Senior Scientist
Technical Training Res Div

PATRICK C. KYLLONEN
Technical Director
Manpower & Personnel Res Div

GARY ZANK, Colonel, USAF
Chief, Manpower & Personnel Research Division

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY (Leave blank)

2. REPORT DATE
June 1995

3. REPORT TYPE AND DATES COVERED
Final August 1992 - June 1994

4. TITLE AND SUBTITLE
Differential Assignment Potential in the ASVAB: A Simulation of Job Performance Gains

5. FUNDING NUMBERS
PE - 62205F
PR - 1121
TA - 12
WU - 00

6. AUTHOR(S)
William E. Alley
Mark S. Teachout

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Armstrong Laboratory
Human Resources Directorate
Manpower and Personnel Research Division
7909 Lindbergh Drive
Brooks Air Force Base, TX 78235-5352

8. PERFORMING ORGANIZATION
AL/HR-TP-1995-0006

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

10. SPONSORING/MONITORING

11. SUPPLEMENTARY NOTES
Technical Monitor: Mark S. Teachout, (210) 536-2932; DSN:240-2932

12a. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution is unlimited

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

The classification potential of the Armed Services Vocational Aptitude Battery (ASVAB) to improve military performance has been the subject of recent controversy. At issue is whether the ASVAB can be configured to provide differential classification value. A simulation study was conducted in which Air Force recruits (N=1250) from eight job specialties were "reassigned" to optimize overall job performance based on their ASVAB test scores. Results from the optimal reassignment yielded average expected performance gains that were 1/2 of a standard deviation unit above that obtained in a random allocation. The performance gain over the current assignment baseline was 1/3 of a standard deviation unit. These gains were equivalent to those that would have been produced if recruits had been given an additional 14 months of technical experience. Implications for force planning were discussed.

14. SUBJECT TERMS
Classification, Aptitude, Ability, Work Sample Tests, Assignment, ASVAB, Experience, Performance Measurement

15. NUMBER OF PAGES
12

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	UL

CONTENTS

PREFACE

The Human Resources Directorate of the Armstrong Laboratory, formerly the Air Force Human Resources Laboratory, developed a Job Performance Measurement System to measure the job performance of first-term enlisted personnel. The measures were designed and developed, and data were collected on the job performance of first-term airmen for eight Air Force Specialties between 1984 and 1987.

This report documents the results of a study conducted to optimize overall job performance of personnel based on their aptitude test scores. This work was performed by the authors under in-house Work Unit No. 1121-12-00.

The authors are grateful to the many government scientists, contract researchers, subject matter experts and base personnel for their support in the design, development and data collection for this project. A previous version of this paper was presented at the annual meeting of the American Psychological Association, August, 1992.

DIFFERENTIAL ASSIGNMENT POTENTIAL IN THE ASVAB: A SIMULATION OF JOB PERFORMANCE GAINS

SUMMARY

This research simulated the effects of using aptitude test scores to optimize overall job performance of first-term enlisted personnel. Optimal reassignment resulted in performance gains above both random assignment and current assignment allocations. Recommendations are made for the more sophisticated use of aptitude data and improved human resource planning.

I. INTRODUCTION

The use of tests for military personnel selection has a well-documented history in the applied literature (Weeks, Mullins, & Vitola, 1975; Welch, Kucinkas, & Curran, 1990). Relatively little attention however has been devoted to the process of classification---allocating applicants to two or more jobs based on differences in the utility of alternative assignments (Zedeck & Casio, 1984). Recent studies relating the Armed Services Vocational Aptitude Battery (ASVAB) to military performance criteria (Hunter, 1985; Johnson & Ziedner, 1990; Johnson, Ziedner, & Scholerios, 1990; Ree & Earles, 1991, Ree, Earles, & Teachout, 1992, 1994; Schmidt, Hunter, & Larson, 1988) have shown equivocal results. Hunter (1985), Schmidt et al. (1988), Ree and Earles (1991) and Ree et al. (1992; 1994) found that specific abilities added marginally to a general ability factor in predicting technical training and job performance criteria but did not document any practical benefits associated with the gain. Johnson and Ziedner (1990) and Johnson et al. (1990) document that non-cognitive measures (interests and psychomotor tests) could add to the classification utility of the ASVAB, if the measures were selected to enhance the differential content of the test. Still at issue, however, is whether the ASVAB in its present form can be configured to provide differential classification value. The purpose of the present study was to demonstrate the potential classification utility of the ASVAB compared to random and current assignment practices and to express the predicted performance gains, if any, in the equivalent experience levels required to obtain them.

II. METHOD

Subjects

First-term enlisted personnel in eight Air Forces specialties ($\underline{N} = 1250$) were followed from entry into service into their first job assignments. The specialties included jet engine mechanic, aerospace ground equipment mechanic, information systems radio operator, personnel specialist, air traffic control operator, avionics communications specialist, aircrew life support specialist and precision measurement equipment laboratory specialist. Ethnic and demographic composition of the group was representative of all Air Force accessions during this period. Males constituted 83% of the group and ethnic mix was 78% white and 22% black or other. Average age of incumbents was 22 years and each had spent an average of 28 months in service.

Performance Measures

The job performance of each incumbent was measured by an in-depth work-sample test designed to assess maximum performance potential under ideal conditions (for a more complete description of these measures see Hedge & Teachout (1986, 1992)). Each test contained detailed step-by-step checklists that specified the conditions, standards, and behaviors for successful performance on a series of tasks representative of the job of the first-term enlistee. Tasks were performed at each individual's work site under the observation of a trained test administrator who scored each step on a correct/incorrect basis. Incumbents were instructed to perform each task according to technical order (TO) procedures. Examinees were individually administered the work-sample tests consisting of 20 to 30 tasks for each specialty. Administration of the tests required approximately 4 to 7 hours with a maximum time limit specified for each task. Summary scores were obtained from the work-sample test and converted within each specialty to a standard score metric (Mean = 50; SD = 10).

Aptitude Tests

Prior to enlistment in the Air Force, each job incumbent was administered the Armed Services Vocational Aptitude Battery (ASVAB) as part of the entry-level screening program (U.S. Department of Defense, 1984). The battery yields 10 subtest scores measuring math and verbal skills and technical knowledge (i.e., auto and shop). ASVAB scores are reported in standard score metrics with a mean of 50, and standard deviation of 10 and are based on a nationwide sample of American youth (U.S. Department of Defense, 1982). Descriptive data on the sample are shown in Table 1.

Table 1. ASVAB Subtest Means and Standard Deviations By Specialty (N = 1250)

	SPECIALTY							
Predictor	JET	AGE	RADIO	PERS	ATC	LIFE	COMM	PMEL
GS	53.3 (6.7)	54.2 (5.8)	50.8 (8.1)	50.2 (7.0)	55.7 (6.3)	52.4 (7.2)	59.7 (5.4)	59.0 (5.1)
AR	54.3 (7.0)	53.8 (6.2)	52.7 (6.5)	52.9 (6.2)	58.8 (5.0)	53.9 (6.2)	60.7 (4.8)	60.4 (4.4)
WK	51.6 (5.7)	52.8 (4.7)	51.9 (5.6)	52.4 (5.6)	55.2 (4.4)	52.6 (5.3)	56.3 (4.7)	56.0 (4.8)
PC	52.3 (5.8)	53.2 (6.4)	53.9 (5.6)	53.6 (5.9)	56.2 (4.6)	53.2 (5.5)	57.2 (4.7)	57.2 (4.3)
NO	51.0 (7.2)	51.9 (6.5)	57.9 (4.4)	57.8 (4.3)	55.6 (5.7)	53.8 (6.3)	55.6 (5.6)	56.2 (6.3)
CS	50.1 (6.4)	51.0 (6.6)	56.6 (6.3)	57.7 (6.1)	54.7 (6.5)	53.2 (7.0)	54.3 (7.1)	55.8 (7.6)
AS	60.5 (6.7)	59.4 (5.9)	49.1 (8.5)	47.7 (8.1)	56.5 (8.0)	52.4 (8.7)	60.9 (5.8)	59.7 (6.8)
MK	51.6 (7.7)	52.8 (7.1)	52.9 (7.7)	53.6 (7.2)	57.1 (6.8)	53.2 (7.5)	61.1 (4.6)	60.7 (5.7)
MC	57.3 (6.9)	57.3 (6.2)	50.4 (8.4)	49.7 (7.6)	57.6 (7.3)	53.2 (8.0)	61.8 (5.5)	61.5 (5.9)
EI	56.1 (7.3)	55.4 (7.0)	49.4 (8.3)	48.1 (7.7)	55.0 (7.6)	52.0 (7.5)	61.3 (6.2)	60.7 (5.9)
EXPER	29.5 (11.2)	28.1 (10.4)	23.8 (13.0)	27.9 (11.8)	26.9 (8.8)	28.7 (11.1)	35.3 14.9)	27.4 (10.7)

NOTE. ASVAB subtests are abbreviated: GS = General Science; AR = Arithmetic Reasoning; WK = Word Knowledge; PC = Paragraph Comprehension; NO = Numerical Operations; CS = Coding Speed; AS = Auto and Shop Information; MK = Math Knowledge; MC = Mechanical Comprehension; EI = Electronic Information. Specialties are abbreviated: JET = Jet Engine Mechanic; AGE = Aerospace Ground Equipment Mechanic; RADIO = Information Systems Radio Operator; PERS = Personnel Specialist; ATC = Air Traffic Control Operator; LIFE = Aircrew Life Support Specialist; COMM = Avionic Communications Specialist; PMEL = Precision Measurement Equipment Lab Specialist. EXPER = Experience.

Experience

Experience measures were recorded as months of service between date of entry into service and the time at which the performance tests were administered.

Analyses

Hands-on work sample performance measures were regressed on the ASVAB subtests and the experience measure separately for each of the eight specialties. The least-squares regression equations were then used to estimate expected performance for all incumbents across all jobs. In this process, job experience was held constant (at 4 years) to equate the estimates for people who had spent varying amount of time in service.

Three different assignment solutions were investigated. First, a baseline was established for comparison purposes which set the average performance of incumbents within each specialty to a standard score metric (Mean = 50; SD = 10). This reflected the efficacy of the current assignment system. Second, a linear programming algorithm (Schrage, 1984) was used to optimize expected performance across all jobs subject to the constraint that all jobs be staffed with the same number of personnel as under the present system. This optimal assignment represented the level of overall performance that might have been achieved by capitalizing on the differential classification potential of the ASVAB. A third "random" solution was obtained by simulating assignments without regard to aptitude. The three solutions were then compared on the basis of the overall average predicted performance across all jobs (Brogden, 1959). Finally, the magnitude of gains in predicted performance were expressed as a function of the amount of job experience needed to achieve similar levels of performance.

III. RESULTS

An initial regression analysis of the aptitude and experience effects on hands-on performance yielded multiple Rs ranging from .36 to .60, all significant at the .01 level (See Table 2). Both aptitude and experience contributed uniquely to the predictions. Results of the assignment solutions (shown in Table 3 and summarized in Figure 1) indicate an increase in overall expected performance between the random and optimized solution of (53.42-48.67) 4.75 units or approximately one-half of a standard deviation unit. A comparison of the current vs. the optimal solution showed a potential performance gain of (53.42-49.99) 3.43 units over the current baseline.

The effects of tenure across jobs, held constant in these comparisons, were substantial. On average, each one-month increment in experience resulted in a .23 unit increase on the performance criterion. Thus, the difference between the current and optimal solutions (3.43 units) was equivalent to what would have resulted if each job incumbent had an additional 14.91 months of technical experience.

Table 2. Summary of Regression Coefficients and Multiple R's by Specialty for Hands-on Performance ($\underline{N}$ = 1250)

	SPECIALTY							
Predictor	JET	AGE	RADIO	PERS	ATC	LIFE	COMM	PMEL
GS	-.028301	.253341	-.179182	-.061659	.129680	-.084853	-.348631	.106354
AR	.242384	-.007492	.298839	.251638	.362410	-.010353	-.008062	.497242
WK	-.127178	-.441997	.347863	.280180	.022794	.078684	.548962	-.345143
PC	-.032372	.090537	.246509	-.090540	-.298409	-.166835	.289150	.031357
NO	.204363	-.316546	-187869	.081718	-.283656	-.080212	.002959	-.039191
CS	.018090	234308	-.196472	.065373	.343687	.098737	-.123094	.162141
AS	.358269	.261129	.011111	.034252	.129287	.038467	.637534	-.034193
MK	-.144909	.213439	.114328	.279252	-.011882	.020605	.624234	.202154
MC	-.058089	.195572	.089420	.019028	.003228	.105186	-.325432	.340653
EI	.077108	.144621	-.179482	-.196798	-.148518	.124659	-.161327	.089314
EXPERIENCE	.175352	.171785	.254366	.337048	.233188	.276851	.191850	.224272
CONSTANT	14.937890	8.654381	25.825945	3.954259	29.522355	35.448814	-23.136714	-18.752804
MULTIPLE R	.362944	.485988	.508041	.508289	.390429	.359307	.598389	.538034

NOTE. ASVAB subtests are abbreviated: GS = General Science; AR = Arithmetic Reasoning; WK = Word Knowledge; PC = Paragraph Comprehension; NO = Numerical Operations; CS = Coding Speed; AS = Auto and Shop Information; MK = Math Knowledge; MC = Mechanical Comprehension; EI = Electronic Information. Specialties are abbreviated: JET = Jet Engine Mechanic; AGE = Aerospace Ground Equipment Mechanic; RADIO = Information Systems Radio Operator; PERS = Personnel Specialist; ATC = Air Traffic Control Operator; LIFE = Aircrew Life Support Specialist; COMM = Avionic Communications Specialist; PMEL = Precision Measurement Equipment Lab Specialist.

Table 3. Average Predicted Performance Resulting From Three Assignment Solutions

		Average Predicted Performance		
Specialty	N	Random	Current	Optimal
JET	193	48.56	50.00	51.90
AGE	218	48.63	50.00	55.32
RADIO	126	51.74	50.01	56.13
PERS	176	49.57	50.00	52.83
ATC	164	49.06	49.88	52.37
LIFE	167	50.44	50.00	50.60
COMM	82	45.20	50.00	56.58
PMEL	124	43.92	49.99	53.60
TOTAL	1250	48.67	49.99	53.42

NOTE: Specialties are abbreviated: JET = Jet Engine Mechanic; AGE = Aerospace Ground Equipment Mechanic; RADIO = Information Systems Radio Operator; PERS = Personnel Specialist; ATC = Air Traffic Control Operator; LIFE = Aircrew Life Support Specialist; COMM = Avionic Communications Specialist; PMEL = Precision Measurement Equipment Lab Specialist.

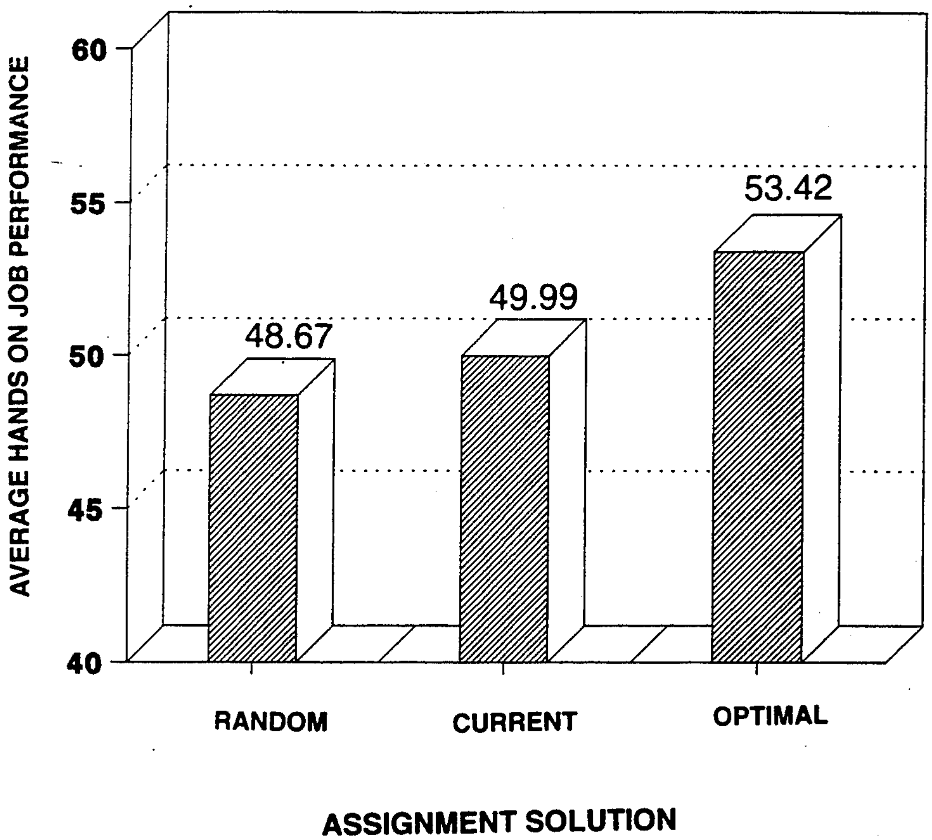

__Figure 1__. **Average Predicted Performance Resulting From Three Assignment Solutions**

IV. IMPLICATIONS

Evidence from the study suggests that even though the ASVAB may be highly "g" loaded (Ree & Earles, 1990; Ree et al., 1992, 1994), it can be configured to provide significant differential validity in predicting hands-on job performance compared to the present or random assignment conditions. The magnitude of the actual gains was consistent with the "ballpark" estimates given by Johnson et al. (1990) in their study using simulated rather than actual data. How much of this potential is currently being realized? In comparing the current assignment value of 49.99 with the random allocation of 48.67, the estimate is about 28% (1.32/4.75 = .28).

There are probably upper limits, however, to how much could be achieved since the classification process must operate within real-world constraints. Applicants exercise some degree of personal preference in accepting job offers---and there are other constraints (i.e., physical and medical qualifications) that might detract from an optimal classification. In an era of force downsizing, however, the services must strive to maintain the highest levels of readiness with a shrinking workforce. More sophisticated use of aptitude data in the assignment process would offer a low-cost alternative to more expensive interventions such as training or job aids in maintaining consistently high levels of performance.

V. REFERENCES

Brogden, H.E. (1959). Efficiency of classification as a function of number of jobs, percent rejected, and the validity and intercorrelation of job performance estimates. *Educational and Psychological Measurement*, 19, 181-190.

Hedge, J.W., & Teachout, M.S. (1986). *Job performance measurement: A systematic program of research and development*. (AFHRL-TP-86-37, A147-175). Brooks AFB, TX: Training Systems Division, Air Force Human Resources Laboratory.

Hedge, J.W., & Teachout, M.S. (1992). An interview approach to work sample criterion development. *Journal of Applied Psychology*, 77, 453-461.

Hunter, J.E. (1985). *Differential validity across jobs in the military.* Report for Research Applications, Inc., in partial fulfillment of DoD contract No. F41689-83-C-0025.

Johnson, C.D., Zeidner, J. & Scholarios, D. (1990). *Improving the classification efficiency of the Armed Services Vocational Aptitude Battery through the use of alternative test selection indices.* (IDA Paper P-2427) Institute for Defense analyses, Alexandria, VA.

Johnson, C.D., & Zeidner, J. (1990). *Classification utility: Measuring and improving benefits in matching personnel to jobs.* (IDA Paper P-2240) Institute for Defense Analyses, Alexandria, VA.

Ree, M.J., & Earles, J.A. (1990). *Relationships of general ability, specific ability, and job category for predicting training performance.* (AFHRL-TR-90-46) Brooks AFB, TX: Manpower and Personnel Division, Air Force Human Resources Laboratory.

Ree, M.J., & Earles, J.A. (1991). Predicting training success: Not much more than g. *Personnel Psychology*, 44, 321-332.

Ree, M.J., Earles, J.A., & Teachout, M.S. (1992). *General cognitive ability predicts job performance*. (AL-TP-1991-0100). Brooks AFB, TX: Human Resources Directorate, Armstrong Laboratory.

Ree, M.J., Earles, J.A., & Teachout, M.S. (1994). Predicting job performance: Not much more than g. *Journal of Applied Psychology, 79*, 518-524.

Schmidt, F.L., Hunter, J.E., & Larson, M. (1988). *General cognitive ability vs. general and specific aptitudes in the prediction of training performance. Some preliminary findings.* Paper presented at the 1988 American Psychological Association Convention, Atlanta, GA.

Schrage, L. (1984). *Linear, integer and quadratic programming with* LINDO. Palo Alto, CA: Scientific Press.

Weeks, J.L., Mullins, C.J., & Vitola, B.M. (1975). *Airmen classification batteries from 1948 to 1975: A review and evaluation.* (AFHRL-TR-75-78, AD-A026470). Lackland AFB, TX: Personnel Research Division, Air Force Human Resources Laboratory.

Welch, J.R., Jr., Kucinkas, S.K., & Curran, L.T. (1990). *Armed Services Vocational Aptitude Batteries (ASVAB): Integrative review of validity studies.* (AFHRL-TR-90-22, AD-A225074). Brooks AFB, TX: Manpower and Personnel Division, Air Force Human Resource Laboratory.

US Department of Defense (1982). *Profile of American Youth: Nationwide administration of the Armed Services Vocational Aptitude Battery.* Washington, DC: Office of the Assistant Secretary of Defense (Manpower, Reserve Affairs and Logistics).

US Department of Defense (1984). *Test manual for the Armed Services Vocational Aptitude Battery.* North Chicago, IL: United States Military Entrance Processing Command.

Zedeck, S., & Cascio, W.R. (1984). Psychological issues in personnel decisions. *Annual Review of Psychology,* 35, 461-518.